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CHICAGO ARTESIAN WELLS.

ON THEIR STRUCTURE AND SOURCES OF SUPPLY.

By LEANDER STONE, A. M.

READ BY THE AUTHOR BEFORE THE CHICAGO ACADEMY OF SCIENCES,
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BY LEANDER STONE, A. M.

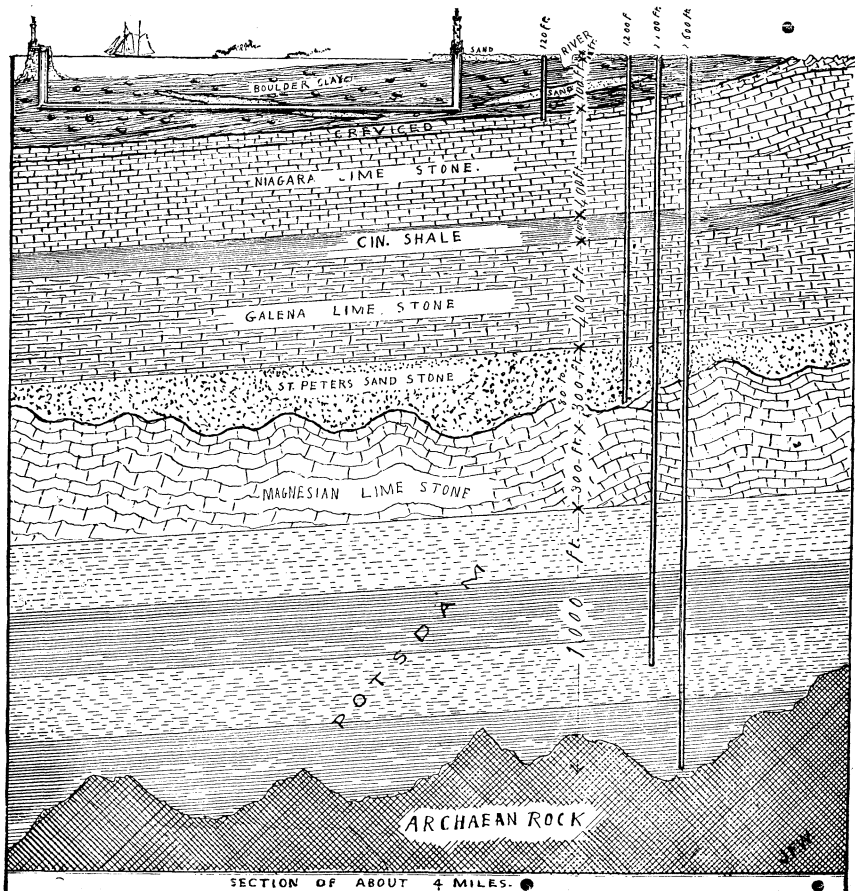
The water supply of Chicago is one of the most important subjects that can engage the attention of its citizens. The lake is the most natural source; but the fact that the greater part of the sewage flows into it, particularly at certain periods of the year, makes the subject of a pure water supply quite difficult.

Something like twenty years ago the first artesian well at the Union Stock Yards was bored, the depth being about 1,200 feet. The flow of water was free and large. A little earlier a well was sunk in the north-west part of the city called "*The Artesian Well*," because it was the first in the city. The object sought was oil, not water; but at the depth of something like 1,200 feet a good supply of water was obtained. Before the fire a considerable number of artesian wells had been made, all of which, I believe, overflowed and gave a very free supply. After the fire a new impetus was given to the business. Wells were bored in a number of places in the heart of the city—at the corner of State and Washington streets, at the Palmer House, at J. V. Farwell's wholesale house on Franklin and Monroe streets, at the Singer building and at other points. Every large packing house in the region of the Stock Yards has one or more artesian wells. There are nineteen in this region alone, yielding each day of ten hours 1,065,000 gallons. Nearly or quite all these wells are pumped to their full capacity, and so made to yield a much larger supply than would be obtained through the natural overflow.

At the parks are several wells—on the West Side, five; Lincoln park, two; South park, one. Nearly or quite all of the distilleries and malt houses have wells, and the total number in the city and immediate suburbs must be nearly or quite eighty. If the ratio of yield were the same in all as at the Stock Yards the total amount of water raised each day

would be about 4,500,000 gallons; but the ratio is much less and an estimate of 3,000,000 gallons each day would be much nearer the truth.

The rocky strata which underlie Chicago, it is well known, are substantially like those of eastern Wisconsin and dip to the east or south-east, rising to the surface at various points at a distance west of lake Michigan. They form the lowest group of distinctly fossiliferous deposits, and are commonly known as the silurian. From the products of the drill in excavating the shafts through these layers, as well as from the out-cropping, it is known that next below the boulder or drift clay lies the Niagara limestone, which is followed in order by the Cincinnati shales, the Galena and Trenton limestones, the St. Peter's sandstone, the lower magnesian limestone, the Potsdam sandstone and the Archaean or Crystalline rocks. The following is a general representation of the proportional thickness of each:



It will be seen that there are in Chicago four different classes of wells, according to the depth. First, there is a considerable number which go no further than just through the clay and into the superficial layers of the Niagara limestone. There are perhaps twenty of these wells, in all of which, with one exception, the water stands at a level not far from that of lake Michigan.

Second, There is a large number which reach down to 1,200 or 1,250 feet and end in or near the St. Peter's sandstone. Nearly all the wells sunk soon after the great fire, and for several years before, were put down to this level and yielded good supplies, which overflowed with various degrees of force and copiousness. It was soon discovered, however, that as the number of wells sunk to this depth increased the flow of those already made decreased, until some ceased to overflow altogether. The well at Central, now Garfield Park, at first rose to a height of forty feet, and yielded forty-three gallons per minute. The supply grew less as new wells were made, until the Park Commissioners tried an experiment to prove whether the supply was common to all the wells. At their request all the wells in the city, with one or two exceptions, were closed for several hours, when it was discovered that the water rose to a considerable greater height than usual in all the wells. This was regarded as conclusive evidence that they were fed by a common reservoir, and also that the water quite freely flowed from one to another. From the time that it became evident that the supply from the old wells would certainly be diminished by every new well, the well-makers turned their attention to ascertaining whether a lower stratum of water-bearing rock could not be found which would yield a supply unaffected by the upper.

New wells were put down to 2,000 and even 2,200 feet, when a supply was found equal or superior to that in the St. Peter's sandstone. This forms the third class of wells.

The fourth class is deeper, and in one case reaches the depth of 2,604 feet, or within thirty-six feet of half a mile. One general fact seems to be borne out by the analysis of the various wells, that the deeper the wells the greater the amount of solid mineral matter. The Lehman well, near the corner of Diversey avenue and N. Clark street, is said to be the deepest artesian well in the State, and the deepest flowing well in the United States. It is 2,604 feet and six inches in depth, and contains in each gallon of water over 322 grains of solid mineral matter, or more than one-half of one per cent. Two hundred gallons of water evaporated, would leave more than a gallon of solid sediment, much more than half of which would be common salt.

Most, or perhaps all, of the wells 1,200 feet deep contain too much lime to permit of the water being used in making steam. The well of Mr. Lehman doubtless extends nearly to the archæan rocks, as represented in

the diagram. I am indebted to the kindness of the Hon. Wm. Bross for procuring for me from the contractors, Gray Brothers, Milwaukee, carefully recorded sections of four wells along the lake shore north of the city. A comparison of the four, one of which is owned by Mr. Bross (the Winnetka well) will afford some interesting statistics. In order that they may be more readily considered I group them together :

	Lake Bluff.	Winnetka.	South Evanston.	Rogers Park.
Clay.....	207	184	74	72
Limestone.....	320	316	316	308
Shale.....	198	192	174	185
Limestone	216	247	228	238
St. Peter's sandstone.....	167	212	458	317
Red marl.....	32	45	12	...
Limestone.....	46	114	84	...
Potsdam sandstone.....	...	356	274	...
Total depth.....	1186	1666	1620	1120

The table is such that read from left to right the order is south and towards Chicago. The Lake Bluff well is something like thirty miles from that of Rogers Park. The Niagara limestone, the Cincinnati shale and Trenton limestone, it will be seen, are quite uniform in thickness. The St. Peter's sandstone shows a great thickening at Rogers' Park and South Evanston, while next below it is a peculiar bed called red marl, which seems to begin somewhere north of Lake Bluff, reaching its maximum depth at Winnetka and thins out at South Evanston, and between that and Rogers Park disappears. This red marl, lying next below the St. Peter's sandstone, is the equivalent of an easily broken unhomogeneous rock which is quite uniformly found in the Chicago well shafts. It seems to be neither sand nor lime, more or less fragmentary and easily crumbled. Mr. Stanford, ex-President of the West Park board, says that in sinking the Garfield Park well to a lower depth this rock was so easily broken down that a cavity of something like a barrel in size was formed before the drill began to perforate the more solid rock below.

In addition to the above classes of wells, it should be said that in the northwestern part of the city, in the vicinity of the old toll gate on Milwaukee avenue, there are several wells yielding a good supply of water at a depth of only about 800 feet. These are all within a half a mile of each other, and I have not learned of any others in the city. The vein appears to be local, and is not met with anywhere else.

The source of the water supply for the lower water-bearing rocks is easily accounted for, since all the lower strata rise to the surface at successive distances west and northwest of lake Michigan, and at altitudes which would give a pressure sufficient to force the water to and above the

surface of the highest bluffs on the coast. In Wisconsin wells have been bored at Sheboygan, Milwaukee, Racine and Kenosha, and the strata, which are water-bearing at a depth of many hundred feet on the coast, crop out in the interior—those at Sheboygan, at Green Lake; those at Milwaukee, at or near Beaver Dam; those at Racine, at Janesville, and those at Kenosha, at the Rock river. These inland points are each enough higher than the surface at the lake to cause an overflow at the lake shore; and artesian wells at points west from the shore grow less in depth as they are distant from the lake. The shallow wells at Oshkosh vary in depth, according to Prof. Chamberlin, and are from 15 to 100 feet.

The wells of Chicago, which pass through the blue clay and "hard pan" into the upper layer of the Niagara limestone, and stop there, have caused some debate as to the source of supply. In these wells, as a rule, the water rises to a point not far from the level of the lake, and thus the opinion has been formed that they are fed from the lake, which backs up through the crevices in the limestone. As the rock is exposed under the water of the lake at various points, such an opinion appears plausible. A careful consideration of the facts only will enable us to form a correct opinion.

The first of these wells was that of Mr. W. F. Bloom, which was made a short time before the great fire. It is situated at the corner of Thirty-fifth and Bloom streets. Mr. Bloom began to dig in the clay in the old-fashioned way, with pick and spade, for water. After he had gone forty feet he came upon the solid rock or hard pan. He then began to drill a shaft $1\frac{3}{8}$ inches in diameter. After passing through two feet of hard pan, two feet of shale and about three feet of limestone the drill dropped a few inches, and a copious supply of water was the result. The water passing up through this small aperture quickly filled the well, some five feet in diameter. Mr. Bloom made a persistent effort to pump the water out, using a common suction pump and a chain pump, and failed to make an impression on the volume of water. He filled the well up to within a few feet of the top with broken bricks and stone, and then made a curb about it. The water is sweet and pure and has never failed, although it has been freely used by the neighbors for many years. It has been supposed that the water stands at a level with the lake and rises and falls with the lake-level.

Some time later Mr. A. S. Piper sunk a similar well a short distance from Mr. Bloom's, at the corner of Ashland avenue and Twenty-seventh street. This well-shaft passes through fifty-six feet of clay and fourteen and one-half feet of rock. The diameter is three inches. A fire engine was employed for some time in a vain effort to exhaust it. It is used to supply a horse barn and about forty horses. The water is pure and good, but I have no analysis.

Mr. F. S. Swalley has constructed a large number of these wells with a bore of six inches through the clay and five inches in the rock. Messrs. Libby, McNeil & Libby, packers, have two wells near Sixteenth and State streets, within about eight feet of each other. The pumping of one does not seem to affect the supply of the other. The wells pass through about ten feet of sand, fifty-five of clay and hard pan, and end thirteen feet in the rock. The water is thoroughly impregnated with iron and sulphur, and cannot be used in steam boilers. The engineer reports that he has several times lighted the gas which rises through the water in the morning after the wells have remained unused through the night. The supply is about forty gallons a minute. There is another of these wells at Twenty-seventh street and the lake, owned by the U. S. Distilling Company. It passes through twenty-seven feet of sand, thirty feet of clay, ten feet of hard pan and thirteen feet of rock. The supply is very small, only about twelve gallons per minute.

Mr. Chas. Pope has one for his malt house at 488 North State street. It is about three hundred feet from lake Michigan, and the water is almost exactly like pure lake water. The Huck Malting Company, corner of Canalport avenue and Eighteenth street, has a well from which the water at one time flowed over the top at a level of about eight feet above the river. It is the only one of the shallow wells that overflows. The shaft passes through ten feet of alluvium, sixty feet of clay, five feet of boulders and hard pan and several feet into the rock. The well yields about forty-five gallons per minute.

Near the corner of Market and Erie streets, on the North Side, is another of these wells, which, after reaching the requisite depth in the rock, about fifteen feet, had to be pumped out completely several times before the water flowed into it freely. The pumping seems to have freed the well from clay which clogged the openings in the rock at the base of the bore.

The wells of the class constructed at Goose Island, on the north branch, are much impregnated with lime and sulphur, and the water cannot be used in steam boilers. One of the finest wells of this class is at Mr. Jennings' laundry, at 405 West Madison street. It passes through ninety feet of clay, six feet of hard pan and fourteen feet of rock—a gray limestone. The water is perfectly soft and pure—softer than lake water. It is used by the proprietor for washing purposes, for which it is much better adapted than the lake water, and the water is sought by many of the neighbors and used in preference to that from the hydrants for drinking and culinary purposes. I asked Mr. Artingstall, the city engineer, if he would not mark a bench at this well, giving the altitude above the city datum, and he very kindly deputized a surveyor to run a level to the well. The mark of the surveyor is 17.454 feet above the lake. This mark is

6.25 feet above the concrete floor where the tube of the well terminates. I was unable to measure the height of the water in the well owing to the fact that it is inaccessible by reason of the pumping machinery; but the foreman said the level of the water when the well was completed, stood about twelve feet from the surface, which would be less than a foot from the lake level. The Jennings well is a prize worth far more than it cost. It seems to have an unlimited supply of water. The deepest of the wells sunk by Mr. Swalley was near the crossing of Larrabee street and North avenue. Here was tried a suggestive experiment. Usually the drill is stopped after reaching from twelve to twenty feet within the Niagara limestone. In this well water was reached at twenty feet, but the flow was only moderate—about nineteen gallons—and to see if it could be increased the drill was sunk seventy feet further, but without augmenting in the least the flow. This experiment seems to prove that the water-bearing rock is superficial and does not exceed about twenty feet. This contractor has put down something over twenty of these wells. Some have failed to yield a sufficient supply to be of any utility—twelve gallons per minute being regarded as the practical minimum. In one case a sand pocket was found in the clay in a boring made near the intersection of Carroll avenue and Ada street, which was not exhausted except by vigorous steam pumping for eight to ten hours. Usually in passing through the clay water had to be supplied to the drill by pouring in at the top. The temperature in all these wells, winter and summer, ranges from 50 to 55 Fahrenheit.

The source of supply for these shallow wells is not altogether easy to settle. The fact that the water stands in them at or very near the level of the lake has given rise to a general belief that the rocks from which the water is derived afford communication by connecting fissures with the water of lake Michigan. It seems, however, that the levels of these wells are not uniform. One overflows at an elevation of eight feet above the lake and others vary more or less. Besides, the quality of the water differs through varying degrees. The water of the well at 405 Madison street is said to be purer and freer from lime than the lake water; while most are too much impregnated with lime or iron to be used for making steam. It is quite certain that the water is affected by the rock which is in close contiguity to the several wells. The diversity of the water seems to afford strong presumptive evidence that the supply is local and not broad and general.

There are various more or less wide areas within and near the city where the Niagara limestone comes to the surface, or so near it as to receive the rain which sinks into the crevices and cracks, which are more numerous in the top layers than in the deeper measures. At Archer avenue and Twenty-fourth street, at Eighteenth and Lincoln streets, in the northwestern portion of the city, and a little further west in Cicero, are

quite wide areas, where the rain falls upon the fissured rocks and sinks into it, and ultimately finds its way below the clay, where the drill of the well-borer meets it. At the quarry of Dolese & Sheppard, in Cicero, south of the Burlington & Quincy railroad, the miners' families get water from wells drilled in the limestone to a depth of thirty feet. Water to the amount of from twenty to thirty pails a day can be procured from these wells in all but the driest times. The water percolates through the rock and into the wells, and, in this case, these wells are not more than twenty or thirty rods from the quarry. As an indication of the amount of water which these exposed rocks carry below the clay, it may be mentioned that on August 2d, when something over five inches of rain fell within twenty-four hours, the steam pump at the Eighteenth street quarry was operated all day Sunday, all of Sunday night and until Monday noon before the quarrymen could work. This engine has a cylinder of ten inches stroke and eight inches in diameter, with sixty strokes a minute. This would raise about 172,000 gallons in twenty-four hours. In a year there is a total rain fall in this country of about forty inches, which would give eight times as much water to carry off in the twelve months. The upheaval which throws up the rocks to the surface where these quarries are, reaches the Desplaines at Lyons, as Dr. Henry M. Barrister reports in the Illinois Geological Survey. This gives a wide area for rain-fall, and would seem to afford a good supply for all the wells yet sunk or likely to be sunk. The conditions seem to be quite similar to those at Oshkosh, Wis., where artesian wells of three kinds are put down, and afford that city its supply of water. The first are sunk to the drift clay and beneath the surface red clay, the depth being about twenty feet; the second are put down through the blue clay to what Prof. Chamberlin calls the concrete, which consists of partially cemented sand and gravel, and lies immediately on the Niagara limestone. The third class is nearly like the shallow artesian wells of Chicago. Prof. Chamberlin says the flow originates in the rock, within from six to twenty feet of the surface. These wells do not overflow, but the water rises nearly to the surface of the ground, and perhaps a foot or two above the waters of lake Winnebago. Prof. Chamberlin thinks the source of supply is to the westward, and less than ten miles distant.

The question of the water supply in the shallow artesian wells is complicated by the fact that frequently sand pockets of large area, filled with gravel, sand and water, are met with imbedded in the boulder drift clay. A few years ago, when the city authorities were constructing a tunnel beneath the north branch, at Division street, for the water mains, at a depth of nineteen feet below city datum, and several feet below the bed of the river, a sand pocket, of dimensions so large as to make the word pocket a misnomer, was found. It was more like a broad stratum. The water rose in the shaft a foot or two above the level of the river, and this was the fact

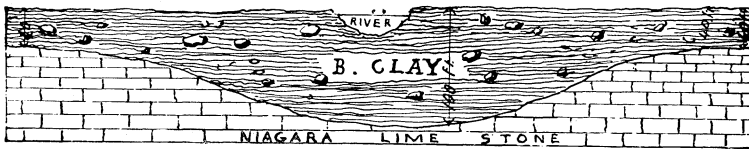
which enabled the city engineer to assume that it was not river water. Two powerful steam pumps, raising together 350 gallons per minute, were set to work, and were kept busy about two days before the water was exhausted, when, at length, it was all removed, and no further trouble experienced ; but in the meantime, the docks for several feet on both banks of the river perceptibly settled, and old wells, which had always yielded water since their construction, were discovered to be dry, and persons living half a mile from the river, to the west, inquired what had been done to drain their wells. The shaft was sunk about seventy-five or eighty feet from the river. Similar trouble was met with when the excavation was made for the pumping engines at Ashland avenue and the south branch, which seems to indicate that the river has something to do with supplying the water.

It appears that the lower sand and limestone measures are formed of alternate solid and impervious layers, and broken and cracked strata. In deepening the well at Garfield Park, a few years ago, the contractor came across a layer of rock which seemed too brittle for the drill to pass through until a large cavity had been broken down and removed. The contractor of the new well recently finished for the West Park Commissioners, in the angle of the boulevard leading from Douglass Park to Garfield Park, says that at a depth of 1,148 feet the drill reached a seam about five feet across. The drill dropped that distance before touching solid rock again. In the meantime the water in the well, which had been overflowing, ceased entirely to reach the surface, and sunk to a level of about three feet from the top, and remained there until the seam was completely shut off by tubing. This well was sunk to a level of 2,317 feet. It contains $196\frac{1}{2}$ grains of solid matter in each gallon of water, more than half of which, or $134\frac{1}{2}$ grains, is common salt. This large seam, and the fact that it caused the overflow to cease for six weeks, or until the water at the seam could be shut off by tubing, is a curious fact.

The boring of so many wells in the city has made it comparatively easy to determine the topography of the surface, were the overlying mass of clay and drift entirely removed. It may be said in general that the Chicago river would flow nearly where it does now if the clay were entirely removed. In other words, the main river and two branches lie over depressions in the Niagara limestone corresponding to the river. The deepest clay is under and on both sides of the river, north and south, and along the branches. In the path of the main river, and for a distance of several squares, either side, it is 100 feet deep and over in some places. At Indiana street and the north branch it is 135 feet deep, and further up the river it ranges from 60 to 70 feet in depth. At Twenty-second street and Canalport avenue it is 100 feet deep ; at Eighteenth street it is 70 feet deep. Between the south branch and the lake, at Libby, McNeil &

Libby's packing house, on State street and Sixteenth, the clay is 55 feet thick, and at the Consumer's Gas Company's well, at Twenty-fifth and Hanover streets, it is 37 feet thick. At 405 W. Madison street it is 90 feet thick. Were the drift wholly removed from the underlying limestone, and the water of lake Michigan kept from flowing in, the surface would be no longer a plane. A rocky knoll over 100 feet in height would appear at Milwaukee avenue and the old Toll Gate, having quite a wide area at top.

The following section across the main river will give a notion of the depth of clay.



Similar high elevations would appear at Eighteenth and Roby streets and at Twenty-fourth street and Archer avenue, while a ridge of rock would extend westward to the Desplaines and Lyons. At Van Buren street, on the South Side, there would be an ascent of sixty feet to a rocky upland at Sixteenth street, extending southward. These ridges are upheavals, as shown by the dip of the strata in general, coinciding with the slant of the surface, as at Archer avenue, Eighteenth street and Cicero quarries, and particularly the rocky ridge of Stony Island, near South Chicago. These elevations were in existence when the drift clay was laid down, as is shown by the planed-off surface of Stony Island, and the fact that the rock thus removed by glacial action is found in the tough clay which is deposited as a tail to this crag in a southwestern direction.

In conclusion, the facts seem to show that the water in the shallowest artesian wells has its source in the limestone outcroppings about and within the city, and partakes of the qualities of the rocks through which it passes in a pretty direct line from the outcropping to the lowest portions of the Niagara limestone. In some cases, as at 405 W. Madison street, the channel is a bed of sand and gravel, and the water is, therefore, very soft and pure. In others, as at the wells at Sixteenth and State streets, where there is iron and inflammable gas, the water doubtless passes through a rock rich in the products of organic remains. The overlying clay rests firmly and everywhere upon the rock and fills the superficial cavities for several feet.